ASAS Centennial Paper: Future needs of research and extension in forage utilization

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ASAS Centennial Paper: Future needs of research and extension in forage utilization

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ABSTRACT: Forage-animal production agriculture is implementing infrastructure changes and management strategies to adjust to increased energy-related costs of fuel, feed grains, fertilizers, and seeds. The primary objectives of this position paper are to assess future research and extension scientific needs in forage utilization, financial support for the discipline, and changing status and number of scientists. A survey questionnaire returned from 25 land-grant universities in the eastern half of the United States rated the top 4 research needs as 1) pasture systems and efficiency of production; 2) interfacing with energy concerns; 3) forage cultivar evaluations and persistence; and 4) environment impacts. Plant-animal future research needs at 11 USDA-ARS regional locations are targeted at sustainable management and improved livestock performance, ecophysiology and ecology of grasslands, environment impacts, and improved technologies for nutritive value assessments. Extension scientists from 17 southern and northeastern states listed the top 3 needs as forage persistence, soil fertility and nutrient management, and pasture systems and efficiency of production. Grant funds currently provide more than 40% of land-grant university research and extension efforts in forage utilization, and scientists estimate that this support base will increase to 55 to 60% of the funding total by 2013. Reduced allocation of state and federal funding has contributed to a reduction in the number of full-time equivalent (FTE) scientists engaged in forage utilization research and extension activities. The current 25 state FTE conducting research number about 2.8 per state. This includes 10 states with >3, 11 states with <2, and 3 states with <1 FTE. Increased interest in cellulosic energy, climate change, and environmental impact may offer new opportunities for these FTE to participate in integrated cross-discipline research Extension programming, and technology transfer methods will change to accommodate reduced funding but with increasing numbers of novice, recreation-oriented landowners.

Key words: Extension, forage, pasture, production, research, utilization

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INTRODUCTION

Research, extension, and education activities associated with forage utilization imply efforts directed at the forage-animal interface. This interface terminology has been used by scientists to describe component relationships and interactions between forages and the grazing animal (Forbes et al., 1985). This common boundary or interface includes physiological, morphological, and chemical characteristics of forages in response to defoliation, performance, treading, and other behavioral aspects of the grazing animal (Forbes and Rouquette, 2007). Thus, as a function of assessing individual and combined components of plants and animals, scientists representing 2 or more disciplines within a university or with other research institutions are collaborating to meet common objectives. A research structure of funding, direction, and accountability must overlay disciplinary "boundary lines" and bring together scientists with a common goal and vision (Burns, 2006).

The objectives of this position paper were to survey land-grant university and USDA regional center scientists to assess future research and extension scientific needs in forage utilization, financial support for the discipline, changing status and number of scientists, and to assess the opportunities and obstacles for future research and education activities.

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Table 1. Priority research needs pertaining to the plant-animal interface as identified by USDA/SAES (1975)

• Increase efficiency of utilization of forage and other cellulosic materials
• Improve management of grasses and legumes
• Develop improved methods of forage quality evaluations
• Develop efficient mechanization of stored forages
• Develop utilization systems for plant and animal wastes
• Develop herd management systems
• Maintain animal health
• Develop grazing and harvesting systems

Table 2. Priority research needs pertaining to the plant-animal interface as identified by USDA/SAES (1977)

• Improve grasses and legumes
• Improve management of range and forage crops
• Reduce limiting factors of production
• Improve management of livestock
• Reduce limiting factors in livestock production systems

BACKGROUND OF NEEDS ASSESSMENT

Multifaceted grazing land concerns and issues confront the producer, consumer, and public sector groups, and include forage and animal production, forage utilization, forage conservation, environmental aspects of forage-animal production, legislative policies, and overall public perception and image (Rouquette et al., 1995). In the past, research, extension, and education issues have received periodic assessment in meetings that focused on planning and prioritization of needs. In 1993, at a national workshop in Airlie, Virginia, Rouquette et al. (1995) projected that future issues and problems for grazing lands programs likely include a decreasing scientist-year allocation to the subject; dramatic reduction in projects and funds for accomplishing objectives; reduced administrative support for production and application-based programs; public opposition to the use of grasslands for red-meat production; nonidentifiable status of grazinglands as a commodity; and lack of a spokesman and leadership for grazinglands at the state and national levels.

Burns (2006) provided a thorough historical documentation and perspective of grazing research in the humid east, and presented the following general progression of the forage-animal discipline: a) a special American Society of Agronomy symposium on pasture techniques and utilization in 1924 (Carrier, 1924; Fain, 1924); b) the first replicated grazing experiment with associated statistical analyses in the *Journal of Animal Science* (Kincaid et al., 1945) and a contribution in the *Journal of American Society of Agronomy* (Petersen, 1947); c) special reports in the *Journal of Animal Science* (Beeson et al., 1950) and a book on pasture and range techniques (Pasture Improvement Committee, 1952); and d) the first replicated grazing experiment published in *Crop Science* (Marten et al., 1981). With the need for emerging growth of the forage-animal interface discipline, and stakeholders eager for forage utilization strategies, multidisciplinary team efforts increased during the 1970s and 1980s. Reflecting this growing emphasis and funding opportunities, a series of taskforces and work groups began to assess and prioritize research and education needs. In a cooperative effort, USDA and state agricultural experiment station (**SAES**) scientists published 2 taskforce reports (USDA/SAES, 1975, 1977) pertaining to the need for plant-animal interface research (Tables 1 and 2).

Growth in forage-animal programs was relatively short-lived. By the late 1980s to early 1990s, the tide had changed and there was a trend of diminishing federal and state funding to support plant-animal interface research and education activities. After the organization of the Grazing Lands Forum, a series of annual forums was held to assess critical issues related to grazing land management and water quality (Grazing Lands Forum, 1986), multiple-use opportunities (Grazing Lands Forum, 1987), research and education needs (Grazing Lands Forum, 1990), and environmental impacts (Grazing Lands Forum, 1991). In 1992, the USDA Soil Conservation Service developed a list of critical issues for a grazing lands conservation initiative for private lands. Grazing management was the most important on a list of 11 issues (USDA-Soil Conservation Service, 1992). About the same time, the American Forage and Grassland Council (AFGC, 1991) research committee listed critical issues and needs. These issues included profitability and sustainability of forage-based agriculture, plant genetics to improve quality and quantity, grassland establishment, grassland management strategies, efficiency of grazing animals, and efficiencies associated with cutting, storage, and feeding mechanically harvested forages.

Also during this period, the 1993 Airlie, Virginia, workshop of USDA and SAES scientists was held and dealt with innovative systems for utilization of forage, grassland, and rangeland resources. Discussion focused on issues pertaining to plant-animal, plant-environment, and plant-society interfaces (Barnes, 1995). Research and education needs identified for the plant-animal interface were concentrated in the general areas of developing and promoting sustainable utilization practices to enhance grassland resources (Rouquette et al., 1995). The specific education needs included dedicated programs to inform urban populations and legislative bodies on land stewardship practices. The broad, generic needs and critical issues associated with the forage-animal interface identified at this workshop are presented in Table 3. In the mid-1990s, the Federation of American Societies of Food and Animal Sciences published a document (FAIR '95; FASFAS, 1995), which included an agenda to link science and technology to societal concerns and benefits.

Table 3. Research and education needs at the plant-animal interface identified by participants at the Airlie, Virginia, conference (1993; Rouquette et al., 1995)

Research and education needs
• Interrelationships of soils, plants, animals, and the environment
• Identification of plant and animal products for direct and indirect consumptive use
• Reciprocal relationships between grazing systems and societal and/or policy issues
Critical issues
• Develop integrated management systems that conserve and/or sustain natural resources
• Develop forage-cropping systems for site restoration, plant and animal production, water quality enhancement, conservation, and erosion control
• Develop environmentally compatible and ecologically sound systems for animal waste disposal
• Develop decision aids to integrate plant-animal performance within boundaries of specific ecosystems
• Develop strategies for implementation of programs and education of the public

A survey questionnaire of 14 southern land-grant universities in 1994 (F. M. Rouquette; unpublished data) and again in 2004 (Rouquette et al., 2004) showed the trends in forage-pasture research emphasis. Although there were some minor trend changes, more than 70% of the research emphasis at land-grant universities was directed toward forage physiology and management, grazing, and forage breeding (Table 4). In 2004, grazing research received comparable emphasis among land-grant and USDA regional centers (Table 5). Within this emphasis on grazing, 60 to 70% of research efforts was directed toward animal performance, forage utilization systems, and forage cultivar evaluations.

LAND-GRANT UNIVERSITY RESEARCH NEEDS

As of June 1, 2008, there were 34 research projects listed as Current Research Information System (**CRIS**) projects (http://cris.csrees.usda.gov/) under the field of forage utilization. However, only 14 of these projects were active and 20 were listed as terminated in 2004 to 2006. An assessment of the objectives of the active CRIS projects revealed that current forage utilization research has been prioritized into the following areas: forage evaluation, grazing systems, management strategies, growing-feeding systems, supplementation, and soil-plant-animal nutrient management.

A questionnaire survey was sent in 2008 to one research scientist at each of 27 land-grant universities in the eastern half of the United States. These states were selected because of the importance of planted forages and pastures in these environments. The assumption was made that research and extension needs for rangelands and public grazing lands required different approaches, and needs in these areas would vary from those of the more-humid southern and northeastern states. In the 2008 survey, scientists were asked to rank forage utilization research needs from a designated list of 11 options and to supplement this list with other areas as deemed appropriate. Additional survey questions addressed existing and projected full-time equivalents (**FTE**) in forage-utilization research, funding sources, and obstacles to continued forage utilization research. Of the 25 states that responded, average ranking of future research needs showed the top 4 areas to be 1) pasture systems and efficiency of production; 2) interface with energy concerns and biofuel; 3) forage cultivar evaluation and persistence; and 4) environmental impact (Table 6). The scientist prioritization of future research needs from the list of 11 options showed some definite separation of emphases. A second tier of 3 dif-

Table 4. Trends in forage-pasture research emphasis (%) at land-grant universities[1]

Research emphasis	1994[2]	2004[3]
Grazing	23	35
Forage breeding	22	19
Forage physiology and management	27	18
Conserved forages	2	6
Basic forage physiology	8	6
Animal waste	3	5
Soil fertility and nutrition	6	5
Economics	1	3
Pest management	0	3
Environment/urban	4	1
Modeling	2	1
Soil microbiology	0	1
Energy and biofuel	1	0

[1]Data are the average percentage of forage-pasture research effort devoted to these emphasis areas.
[2]Survey conducted in 14 southern states (F. M. Rouquette, unpublished data).
[3]Survey conducted in 13 southern plus 3 midwestern states (Rouquette et al., 2004).

Table 5. Grazing research emphasis (%) at land-grant universities and USDA regional centers in 2004[1]

Research objectives	Land-grant (n = 14)	USDA centers (n = 7)
Animal performance	29	25
Forage utilization systems	18	26
Stocking rates	11	6
Animal reproduction	11	4
Forage cultivar evaluations	10	20
Intake, digestion	8	11
Soil fertility	6	2
Animal behavior	5	5
Animal health	2	2

[1]Survey conducted in 14 southern land-grant universities and 7 USDA regional centers (Rouquette et al., 2004).

Table 6. Current and future research needs in forage utilization identified by scientists from 25 land-grant universities in 2008

	Prioritized rank[1]	
Research need	Current	Future
Pasture systems, efficiency of production	3.3	3.5
Interface with energy concerns; biofuel	6.2	4.2
Forage cultivar evaluations; persistence	3.3	4.3
Environment impacts	5.6	4.5
Soil fertility; nutrient management	6.2	5.2
Animal performance; behavior	4.0	5.3
Stocking methods; stocking strategies	6.3	6.4
Niche marketing for beef; carcass attributes	7.4	8.0
Stocking rates	7.7	8.2
Databases for the future; modeling	9.7	9.3
Compatibility with urban encroachment	9.4	9.3

[1]Rankings represent average of 25 states with the smallest number representing the greatest need.

ferent needs including soil fertility and nutrient management, animal performance, and stocking methods and stocking strategies were closely ranked. The least important needs for future research had close agreement among the 25 states and included niche marketing for beef and carcass attributes, stocking rates, compatibility with urban encroachment, and databases for the future and modeling. These prioritized rankings of current and future research needs were further supported by the frequency with which a need was ranked in either the top 4 or the bottom 4 of the list of 11 needs (Table 7). Pasture systems and efficiency of production was ranked in the top 4 future needs by 17 state scientists, and research needs on interfacing with energy concerns and biofuel, and forage cultivars and persistence were ranked in the top 4 objectives by 16 and 14 states, respectively. A resounding separation of the top-ranked needs and the least-needed research was also evident with an increased frequency of ranking them as low-priority needs. Research needs that were most frequently ranked in the bottom 4 included compatibility with urban encroachment (18); databases for the future and modeling (17); stocking rates (13); and niche marketing for beef and carcass attributes (11). Some states included top-ranked needs associated with legume and ecosystem evaluations, which were considered to be subunits of forage cultivar evaluations and persistence. An increased emphasis in forage legume evaluations that target persistence under grazing, tolerance of acid soils, adaptation to various climatic conditions, and rhizobia-plant efficiencies for N fixation will be high-priority needs as fertilizer costs continue to increase. Similarly, perennial grasses that are productive and sustainable under reduced to no N fertilizer applications are high-priority research needs. The future research needs prioritized by 25 state scientists in 2008 had some baseline similarities to those proposed more than 30 yr earlier with respect to pasture use efficiency and forage evaluation. Burns (2006) provided some priority needs for grazing experimentation that included specific plant-animal interface relationships that were also included by responders in 2008. These pasture use efficiency directions include aspects of plant persistence, nutritive value, DMI, fiber digesta kinetics, grazing behavior, diet selection.

The following responses were summarized from 25 states in response to the question, what is the most important need for future research on forage utilization?

1. Twenty-five percent emphasized the need for management strategies to enhance efficiency of forage use, including reducing dependency on fertilizers for environmental and economic implications, and for nutrient management.
2. Twenty-five percent suggested a continued need to evaluate forage germplasm for persistence and nutritive value with emphasis on supplying the nutrient requirements for beef and dairy animals.

Table 7. Ranking frequency of future research needs allotted to the top or bottom 4 priorities by 25 scientists at land-grant universities, 2008

	Ranking frequency[1]			
	Top 4		Bottom 4	
Research need	Current	Future	Current	Future
Pasture systems, efficiency of production	17	17	3	5
Interface with energy concerns; biofuel	7	16	10	4
Forage cultivar evaluations; persistence	20	14	1	3
Environment impacts	10	12	7	2
Soil fertility; nutrient management	9	12	9	5
Animal performance; behavior	15	9	2	5
Stocking methods; stocking strategies	8	8	9	8
Niche marketing for beef; carcass attributes	5	3	10	11
Stocking rates	3	2	11	13
Compatibility with urban encroachment	1	1	18	18
Databases for the future; modeling	0	1	16	17

[1]Frequency that a research area was ranked in the top 4 or bottom 4.

3. Twenty-one percent indicated an urgent need for more state and federal-based funding to provide consistency of effort and to reduce the uncertainties of funding that disrupts and terminates programs.
4. Thirteen percent suggested that more grant opportunities and funding were needed; however, they cautioned that often these funds may not benefit stakeholders near the local research site. It was also added that administrators often make personnel decisions based on project opportunities for grant funding.
5. Eight percent cited the need for stakeholder involvement for the purpose of encouraging administration to provide state funding support for programs.
6. Eight percent indicated the need for cellulosic research and areas related to bioenergy.

USDA-ARS RESEARCH NEEDS

Research conducted by USDA-ARS scientists focused on improving production efficiency and profitability of forage-based livestock production is coordinated by 2 National Programs; NP 101 (Food Animal Production) and NP 215 (Rangeland, Pastures, and Forages). All ARS research projects are composed of one or more experiments (subobjectives) that address an overall objective(s). Projects for a National Program are conducted in 5-yr cycles. The 1998 Farm Bill (*The Agricultural Research, Extension, and Education Reform Act of 1998*) required that procedures of project plans be peer-reviewed for scientific merit and programmatic relevance. In response to this mandate, ARS established the Office of Scientific Quality Review to manage and implement the review process. Before project plan preparations, National Programs organize focus group meetings for ARS scientists and administrators to obtain input from industry leaders and stakeholders for establishing objectives that meet the needs of agriculture.

Research on forages, including introduced and planted native species, is being conducted at 11 different ARS locations, and there are presently 53 projects across these locations. Twelve projects include collaboration between ARS and university scientists through specific cooperative agreements. Grazing experiments are included in 28 of the projects, with an emphasis on the development and evaluation of sustainable management approaches that improve livestock production on pastures. Thirteen projects used grazed pastures or small plots to study defoliation effects on ecophysiology or ecology of grasslands. Furthermore, some of these programs are using molecular techniques to study the genomics, proteomics, and metabolomics of forage plants. Four projects are focused on the environmental impact of grazing or use of animal waste for fertilizing pastures. Digestion trials, pen studies, or laboratory studies are being conducted in 6 projects to evaluate technologies for improving quality of grazed or conserved forages.

During the past 15 yr, the Forage Research Unit in Starkville, Mississippi, was redirected into animal waste research, and the Tobacco, Forage, and Turfgrass Research Unit in Lexington, Kentucky, was closed. However, the Forage-Animal Production Research Unit was recently opened in Lexington, and the US Dairy Forage Research Center at Madison, Wisconsin, experienced significant increases in funding. Although USDA-ARS has not increased the number of project plans with an emphasis on forage-based livestock production, neither has it had a significant decline in these plans over recent decades. It should be emphasized that the relevance of this research effort by the agency will be driven by demands and need of the stakeholders.

LAND-GRANT UNIVERSITY EXTENSION NEEDS

A survey of extension specialists from 17 land-grant universities showed future program emphases for extension activities related to forage utilization (Table 8). Forage persistence was ranked as the primary need for extension education activities for stakeholders with a 100% program ranking by states. Receiving nearly 90% of top rankings from the states were soil fertility and nutrient management, pasture systems, and efficiency of production. The top-ranked extension needs were similar to the top 4 research needs. This close agreement between 25 research scientists and 17 extension specialists reveals the close communication among scientists and recognition of stakeholder needs. This close agreement on future needs should be highlighted as both research and extension scientists are aware of needed parameters of forage utilization to enhance biological efficiencies and economic returns. Also noteworthy were the bottom 3 extension needs in which little emphasis was perceived to be required. These included niche marketing of beef and carcass attributes, compatibility with urban encroachment, and databases for the future and modeling efforts; these were also the bottom-ranked research needs.

FUTURE FORAGE-ANIMAL SCIENTIST FORCE

In a questionnaire survey of 14 southern land-grant universities in 1994 (F. M. Rouquette; unpublished data), respondents provided information regarding scientist FTE for 1984 and 1994. Using information from 17 of these same regional states in 2004 (Rouquette et al., 2004), the long-term reduction in FTE scientists in forage-related positions was evident (Table 9). Thus, from 1984 to 2004 there was a nearly 50% reduction in FTE in research from an average of 7.2 to 3.7 FTE scientist per state, and in teaching from a state average of 1.1 to 0.7 FTE scientist. The 2008 survey of scientists from 25 land-grant universities requested

Table 8. Future extension program needs in forage utilization as identified by 17 state extension specialists from southern and northeastern land-grant universities in 2008

	Prioritized rank	
Extension need	States, n	States, %
Forage persistence	17	100
Soil fertility; nutrient management	15	88
Pasture systems; efficiency of production	15	88
Stocking methods	12	71
Stocking strategies	12	71
Forage cultivars	11	65
Stocking rates	11	65
Interface with energy concerns; biofuel	11	65
Novice landowner	11	65
Niche marketing for beef; carcass attributes	7	41
Compatibility with urban encroachment	4	24
Databases for the future; modeling	4	24

information on the current number of scientist FTE conducting forage utilization research and asked for an estimate of FTE anticipated in 2013. Compared with the 1994 and 2004 assessments, there has been a continual decline in 2008 FTE research scientists involved with forage utilization research at land-grant universities (Table 10). With a 2008 state average of 2.84 FTE in research, the number of scientists per state was estimated to decline by another 0.2 FTE in the next 5 yr. Currently, there are 10 states with >3 FTE, 8 states with <2 FTE, and 3 states with <1 FTE. Projections of FTE by 2013 remain relatively unchanged except for 3 states that have >3 FTE and expect to lose 1 FTE each. From the 25 land-grant university questionnaires returned, there was 1 state in which there was no FTE conducting forage utilization research, and 1 state with 0.2 FTE in forage utilization research. The number of FTE scientist in SAES forage utilization programs may become more variable from state to state. Filling vacant positions or expanding programs is dependent upon individual state budgets and stakeholder support. In response to a question asking if their state was likely to participate in regionalization of research efforts in light of reduced funding, 76% indicated yes, 16% indicated no, and 8% indicated maybe. There are indications that some regionalization of effort is currently underway among states. Almost without exception, forage utilization research is being conducted by scientists in departments of animal science and plant-soil science. In 2008, 65% of forage utilization research was being conducted off-campus and 35% at on-campus sites. The average among states in which forage research is being conducted indicated 1.6 on-campus locations and 3.7 off-campus locations per state.

Survey information from across the humid eastern, midwestern, and northeastern United States indicated a declining number of extension FTE working with forage-animal activities (Table 11). From 1998 through 2008, extension FTE declined 28% from an average of 4.3 to 3.1 per state. It was estimated that there will be a continual decline in extension FTE so that by 2018, the state average will be approximately 2.3 per state. This decline represents a potential 47% decrease in extension FTE scientists during the 20-yr period of 1998 to 2018. While this decline continues, there is an increased need for technology transfer regarding the forage-animal interface to an entirely different class of stakeholders. Whereas extension specialists have traditionally worked primarily with rural clientele who had a reasonable knowledge-base regarding resource management, recent information (Wilkins et al., 2000) indicated that increasing quantities of the rural landscape have been fragmented and subdivided into ownership for recreational purposes. This new and often novice clien-

Table 9. Average number of full-time equivalent (FTE) forage-related positions per state at land-grant universities in the Southern United States

	Average FTE per state		
Area	1984[1]	1994[1]	2004[2]
Research	7.2	5.3	3.7
Teaching	1.1	0.8	0.7

[1]Survey conducted of 14 southern states (F. M. Rouquette, unpublished data).

[2]Survey conducted of 13 southern plus 3 midwestern states (Rouquette et al., 2004).

Table 10. Average number of full-time equivalent (FTE) scientists per university conducting forage utilization research at 25 land-grant universities, 2008

	Year	
Research FTE	Current (2008)	Estimated (2013)
Average per state, n	2.8	2.7
States with >3, n	10	7
States with 2 to 3, n	4	7
States with 1 to 1.9, n	8	7
States with 0.1 to 0.9, n	2	3
States with 0, n	1	1

Table 11. Average number of full-time equivalent (FTE) scientists conducting forage-utilization extension programs at 17 land-grant universities, 2008

Year	Extension FTE[1]
1998	4.3
2008	3.1
2018	2.3

[1]Actual FTE for 1998 and 2008; estimated FTE for 2018.

Table 13. Obstacles (by percentage contribution) to continued research on forage utilization as ranked by 25 land-grant university scientists, 2008

Support group	Research obstacles
Extramural funding agencies	50
Administration	27
Commodity group	15
Clientele	8

tele has little or no understanding of soil-plant-animal management systems. Thus, at a time when extension forage-animal specialists may be in greatest demand, the land-grant university system has reduced state-federal funding and allowed a decline or reappointments of FTE scientists. To counter the trend for reduced extension FTE, there will likely be increased dependence on distance educational programs and increased use of the Internet for information dissemination. Additionally, where similar soils and climate exist, multistate regional appointments for extension specialists may be an alternative decision by state administrations.

FUNDING SOURCES AND AVAILABILITY

Funding sources for forage utilization research from 25 land-grant universities are shown in Table 12. Reduced state funding for agricultural research that began in the late 1980s and early 1990s caused scientists to seek extramural funding sources for all research programs. The current status and future direction for forage-utilization research is that funding will become more grant-dependent. Estimates for future funding were about 55% from grants and 20 to 30% each from state and federal sources. For some states, forage utilization research is almost exclusively supported by grant funds. Although the mission statements of SAES may remain intact on archived policy statements, the reality is that support has dramatically shifted from state to grant-funded, researchable areas. Thus, forage utilization research must attach to and identify with semi-related fundable items, or become a subsidized research emphasis. Researchers will have to be persistent in maintaining programs that are mission-oriented and relevant by using extramural funding that may have only partial identification with the targeted forage utilization. These grant-fundable researchable areas are short-term and preferably include indirect cost recovery by the university or agency.

In the early 1990s, Reichelderfer (1993) suggested that unless the agricultural research agenda becomes associated with practical problems of a contemporary, urban-suburban public, then it will become more difficult to generate and maintain funding for long-term and basic agricultural research. The 2008 questionnaire indicated that the biggest obstacles for continued support for forage utilization research were securing grants, lack of strategic prioritization by administration, inadequate commodity group support, and lack of clientele involvement for state and federal funding initiatives (Table 13). Current and future funding sources for extension programs indicated an increasing dependency on grants (Table 14). Unlike research funding sources, extension faculty predict that only about 5% of their future funding will come from federal sources. In addition, they perceive that more time will be required in writing grant proposals to maintain viable extension programming efforts.

The mid-May 2008 USDA cattle on feed report showed that one-third of the BW groups of cattle entering the feedlot weighed in excess of 365 kg. The sharp decline in light-weight (<270 kg) feeder cattle from 21% in 2007 to 17% in 2008, and the fact that 33% of feeders weigh 365 to 410 kg at feedlot entry are indicators of feedlot industry infrastructure that seeks cattle with more BW gain from pasture and potentially fewer days on feed. More than 70% of the lifetime BW of beef is spent on forages, and 100% of the cow and bull life are spent on pastures or conserved forages. In Texas, for example, 2007 was a record year for agricultural production at $21.8 billion (http://agnews.tamu.edu; accessed May 14, 2008). The value of all crops totaled $10 billion with beef cattle at $7.1 billion. The cash receipts for forage-dependent beef cattle were nearly triple that of either cotton or feed grains. Several of the less-valued commodities compared with beef cattle, however, receive substantially more extramural funding opportunities for research. A more closely aligned

Table 12. Current and future funding sources (%) as rated by 25 land-grant university research scientists, 2008

Funding source	Current	Future
State appropriated	30	25
Federal funds	26	20
Grants	44	55

Table 14. Current and future funding sources (%) for extension programs in 17 land-grant university systems, 2008

Funding source	Current	Future
State appropriated	45	35
Federal funds	12	5
Grants	43	60

relationship between scientist and state and national beef industry organizations is warranted to better serve stakeholders.

FORAGE-ANIMAL AGRICULTURE CRISES AND PARADIGM SHIFT

The rapid acceleration of energy costs in 2007–2008 has created a major forage-animal production crisis in the United States as in other sectors of the economy. Increased costs and reduced availability of feed grains for feedlot rations, fertilizers for pasture, hay, and silage production, and fuel for forage and animal transportation and harvest have resulted in economic chaos in every component of forage-based beef systems. With alternative use of corn and other feedgrains as biofuel seedstock, the price of corn has risen dramatically, and the use of distillers by-products for feedlot rations has substantially altered feedlot management strategies. The paradigm shifts that are apparent for the feedlot industry include consideration of change in feedlot rations, days on feed to finish, and quality grade status of beef products. The paradigm shift also includes a declining cattle inventory. Systems and practices that optimize forage use and management strategies for biological and economic efficiency are paramount for the cow-calf and stocker components. One of the ironies of the cattle industry infrastructure paradigm shift is that based on stakeholder requirements in a time of rapidly increasing energy costs and clearly delineated research and extension needs, there has been reduced financial support for scientists engaged in the plant-animal discipline. As scientists seek extramural grant funding to maintain programs and projects, they tend to migrate toward the fundable issues and objectives although many of these might not be priorities for traditional agricultural production or for emerging clientele groups. This objective-driven drift in program emphasis has become a choice of survival by researchers. Thus, needed research related to forage utilization becomes secondary or does not occur because of lack of funding. Discipline survival will depend on "legislative champions" who have vision and concern for stakeholder benefits and who have opportunities to increase state and federal funding. These issues are related to management strategies, nutrient management, and biological and economic efficiencies of production under current and future conditions of increasing prices for land, fertilizer, fuel, and feed grains. Although there are some state commodity groups that recognize and promote forage utilization and animal performance from pastures, most forage-beef commodity support has been targeted at the end product. Thus, efficiencies of forage utilization and animal performance have become nonfunded issues for the beef industry. State and federal agricultural administrations have not been successful in including the forage-animal production emphases in new initiatives for funding. And, in the era of energy-related research, genomics, and other urban legislator-friendly areas, there are increasingly fewer opportunities for funding of "grass-roots" agricultural programs.

As the structure and knowledge base of stakeholders change with urban encroachment, there is an ever-increasing need for qualified extension personnel to provide educational workshops and specific one-on-one responses to queries. With fewer extension personnel, however, educational programs will become larger, and there will likely be a reduced capability for the one-on-one instruction that has been a hallmark of extension activities. Accompanying the decrease in state extension FTE in forage utilization, alternative methods and major shifts will occur in the methods of delivery of educational information. More stakeholder meetings will likely include Web-based programs, distance education, and regional instructions involving multiple states; private consultation by nonuniversity personnel will increase. With rapidly increasing fuel costs, extension budgets will mandate less travel and more emphasis on multicounty meetings, and many of these programs will likely be conducted via Internet technology. Additionally, the cost of fuel has similar impacts on stakeholders who may chose to receive educational information via computer-based instruction rather than travel to group meetings.

The projections from the 1993 Airlie, Virginia, workshop and the needs assessments from the 2008 questionnaire survey have remarkable similarities. The summary of both efforts has emphasized that future issues and needs for forage-animal programs include a decreasing FTE allocation to the subject; dramatic reduction in number of projects and funds specific for accomplishing objectives; reduced administrative support for production and application-based programs; nonidentifiable status of forage-animal emphases as a commodity; and lack of a spokesman and leadership for forage-animal production at state and national levels. Requirements for research scientists are to remain persistent and dedicated to the mission of discovery and implementation of components to management systems of the forage-animal interface. These requirements are likely to be accomplished via skillful and successful grantsmanship on the boundaries and borders of the plant-animal interface in which the primary goal may actually pertain to a different funding objective. A paradigm shift in the forage utilization discipline is currently underway as scientists pursue these boundary funding areas. One of the most critical needs associated with forage utilization is that of training new scientists who can cross discipline boundaries and address both basic and application research questions. By 2018, nearly half of the existing forage utilization scientists will retire. Land-grant university administration vision, state and federal initiatives, stakeholder actions, and special commodity funding will determine the extent of survival of the research and extension activities in the plant-animal interface discipline of forage utilization.

Forages and grasslands represent a major renewable, natural resource in the United States. Although land

fragmentation is occurring, some of the opportunities for new scientists and project emphases include 1) nutritive value assessments and technologies for plant components to enhance performance of beef, dairy, horses, and other ruminants; 2) plant evaluations and selection for lignocellulosic content and potential for biofuel; 3) quantification and accounting of an array of factors affecting the environment and including water quality and carbon sequestration; 4) intake and digestion of forages as affected by rumen bacteria and fiber components; and 5) overall efficiency of animal performance on forages that may provide some early detection of expected performance. Research and extension scientists in forage utilization will encounter new obstacles and new opportunities to serve a changing pasture environment, stakeholder, and economy. Meeting research and extension forage utilization needs for the future will depend on numerous factors and conditions; however, discipline and program success will be largely attributable to increased communication with state and federal legislators, stakeholders, and commodity groups for sustainable funding opportunities.

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